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The Sangamon interglacial vertebrate fauna from Rancho la Brisca, Sonora, Mexico

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Abstract. Bones of 51 species of vertebrates including fish, amphibians, reptiles, birds, and mammals were recovered from a sedimentary deposit at Rancho la Brisca in north-central Sonora, Mexico. The fauna was preserved in a marshy ciénega habitat with 49.0% of the species and 87.2% of the identified bones representing aquatic and semiaquatic animals. The most common animals in the fauna are *Kinosternon sonoriense* (Sonoran Mud Turtle) and *Rana "pipiens"*-complex (Leopard Frog).

The presence of *Bison* species (Bison) in association with *Mammuthus* species (Mammoth), *Equus* cf. *tau* (Pygmy Onager), and *Camelops* species (Camel) places the fauna in the Rancholabrean Land Mammal Age. *Bufo* cf. *kelloggi* (Little Mexican Toad), *B. mazatlanensis* (Sinaloa Toad), *Leptodactylus melanonotus* (Sabinal Frog), *Pternohyla fodiens* (Burrowing Treefrog), and *Masticophis* cf. *mentovarius* (Tropical Whipsnake) are subtropical thornscrub or Sonoran Desert animals that presently occur to the south and/or west of la Brisca. *Bufo alvarius* (Colorado River Toad), cf. *Callisaurus draconoides* (Zebra-tailed Lizard), and *Sceloporus* cf. *clarkii* (Clark's Spiny Lizard) are other Sonoran Desert animals that suggest a paleoclimate with warm winters and a well-developed summer monsoon. The best modern analog for the paleocommunity would be about 240 km SSE on the Río Yaqui. The subtropical elements in the la Brisca fauna make it unlikely that the fauna was deposited during a glacial period, considering that the Late Wisconsin paleoclimatic reconstructions for Arizona based on plant remains in packrat middens suggest glacial climates with mild, wet winters and cool, dry summers. The fauna represents an interglacial environment subsequent to the appearance of *Bison* about 150 000 years ago in the Sangamon Interglacial and with a climate similar to that of the Late Holocene of the last 4000 years.

The distributions of fish and mud turtles suggest past stream connections between the Gila River drainage in southeastern Arizona and the rivers in Sonora. In contrast, *Pseudemys scripta* (Yaqui Slider) apparently never entered Arizona, although it reaches north-central Sonora today.

Resumen. Un depósito aluvial en Rancho la Brisca, Sonora, ha producido fosiles de 51 vertebrados. Se incluyen peces, amfibios, reptiles, mamíferos, y aves. El 49% de la especies y el 87.2% de los huesos identificados pertenecen a animales acuáticos o semiacuáticos, confirmando la surgerencia que el yacimiento representa una ciénega. Los huesos mas corrientes pertenecen a *Kinosternon sonoriense* (Tortuga de Barro Sonorense) y *Rana "pipiens"*-complex (Rana Pardal). La fauna se refiere a la edad de mamiferoterrestre de Rancholabrea implicado por las presencia de *Bison* species (Bisonte) con *Mammuthus* species (Mamut), *Equus* cf. *tau* (Caballo), y *Camelops* species (Camello).

Bufo cf. *kelloggi* (Sapito Mexicano), *B. mazatlanensis* (Sapo Sinaloense), *Leptodactylus melanonotus* (Rana Sabinal), *Pternohyla fodiens* (Rana Arborea Minera), y *Masticophis* cf. *mentovarius* (Elicante) se ubican hoy al sudeste de la Brisca en el Desierto Sonorense o en al bosque espinoso. Se incluyen tambien otros animales del Desierto Sonorense como *Bufo alvarius* (Sapo del Río Colorado), cf. *Callisaurus draconoides* (Lagartija con Cola de Cebra), y *Sceloporus* cf. *clarkii* (Lagartija Espinosa de Clark). Estos animales indican un clima en cual las temperaturas del invierno son moderadas y occurren fuertes lluvias estivales.

Clima semejante al que se sugiere en encuentra 240 km SSE cerca el Río Yaqui. El yacimiento probablemente no se formo en periodo glacial ya que se encuentran varios elementos subtropicales. Reconstrucciones del clima de Arizona durante el periodo Wisconsin insinuan el mayor porcentaje de

la precipitación anual en el invierno, temperaturas moderadas en el invierno, y veranos secos pero atemperados. La fauna en vez se refiere a un interglacial después de 150 000 años en el Sangamon Interglacial y con clima semejante al Holoceno Ultimo hace 4000 años a hoy. Las distribuciones de los peces y tortugas de barro sugieren conexiones históricas entre los desagues de Arizona y Sonora. Sin embargo, *Pseudemys scripta* (Resbalador Yaqui) no aparece en Arizona aunque hoy se encuentra en la parte norte-central de Sonora.

Introduction

In 1975, a vertebrate fossil locality near Rancho la Brisca was discovered during a survey of the archaeological and paleontological resources of the Río San Miguel drainage in Sonora, Mexico, by the Centro Regional del Noroeste of the Instituto Nacional de Antropología e Historia in Hermosillo. We report specimens collected from 1975–1982 (Table 1). In June 1978, 29 burlap bags of sediment were washed through fine mesh (ca. 2 mm) screens to recover bones of small vertebrates. Most of the fossils have been deposited into the vertebrate paleontological collections in the Instituto de Geología in Mexico City (IGCU 2546–2601). Individual specimen numbers were not provided and have not been included in the text for specimens deposited in this collection. Duplicate specimens and casts are in the University of Arizona Laboratory of Paleontology (UALP) collections. The site is UALP locality #7627; all specimen numbers in the text are UALP catalog numbers. The amphibian, reptile, and small mammal material was identified using Van Devender's osteological collection (TRV). Terminology for most of the anuran post-cranial elements follows that of Gaup (1896). Bird remains were identified using Rea's osteological collection (AMR). Fish remains were compared to skeletons at the University of Michigan Museum of Zoology (UMMZ). Extinct mammals and birds were identified by comparison with fossils in the UALP and the Los Angeles County Museum (LACM) collections. The present distributions of amphibians and reptiles in Sonora were determined from specimens in the herpetological collection in the Department of Ecology and Evolutionary Biology, University of Arizona (UAZ). Extinct animals in the systematics section are marked by daggers (†).

Environmental Setting and Geology

The fossil locality is in north-central Sonora near Rancho la Brisca on the Río Santo Domingo, an upper tributary of the Río San Miguel (Fig. 1). Rancho Agua Fria and the old mission site of Saracachi are 5 km S where there is a large ciénega (marshy area) in the stream valley (Fig. 2). The site is 33 km NE of Cucurpe, 180 km NNE of Hermosillo, and 90 km S of the United States border.

The vegetation at the site is a desert-grassland at about 1000 m elevation that is between the Arizona Upland subdivision of the Sonoran Desert (Shreve 1964) and Mexican oak woodlands (Fig. 3). Important perennials on the slopes near the site include *Prosopis velutina* (Velvet Mesquite), *Juniperus erythrocarpa* (Redberry Juniper), *Mimosa biuncifera* (Wait-a-minute Bush), and *M. dysocarpa* (Gatuno). *Quercus emoryi* (Emory Oak or Bellota), *Celtis reticulata* (Netleaf Hackberry), and *Juglans major* (Arizona Walnut) are on areas with deeper soil below. *Salix nigra* (Goodding Willow), *Fraxinus pennsylvanica* (Velvet Ash), *Populus fremontii* (Frémont Cottonwood), and, locally, *P. monticola* (Sonoran Cottonwood), occur along the Río Santo Domingo. The canyon flora includes *Ficus petiolaris* (Fig) at its northern limit and occasional *Acer grandidentatum* (Big Tooth Maple) at its southern limit. The stream is perennial and harbors such species as *Gila purpurea* (Yaqui Chub), *Rana "pipiens"*-complex (Leopard Frog), *Kinosternon sonoriense* (Sonoran Mud Turtle), and *Thamnophis cyrtopsis* (Black-necked Garter Snake). A disjunct, southern population of *Sciurus arizonensis* (Arizona Gray Squirrel) lives in the riparian trees. The area is used mostly for grazing with some local agriculture and gold mining.

Climatic records for Saracachi at 930 m elevation are available in Hastings and Humphrey (1969). The mean annual temperature is 16.5°C; the coldest and hottest months are January (8.3°C) and July (25.3°C), respectively. The mean annual precip-

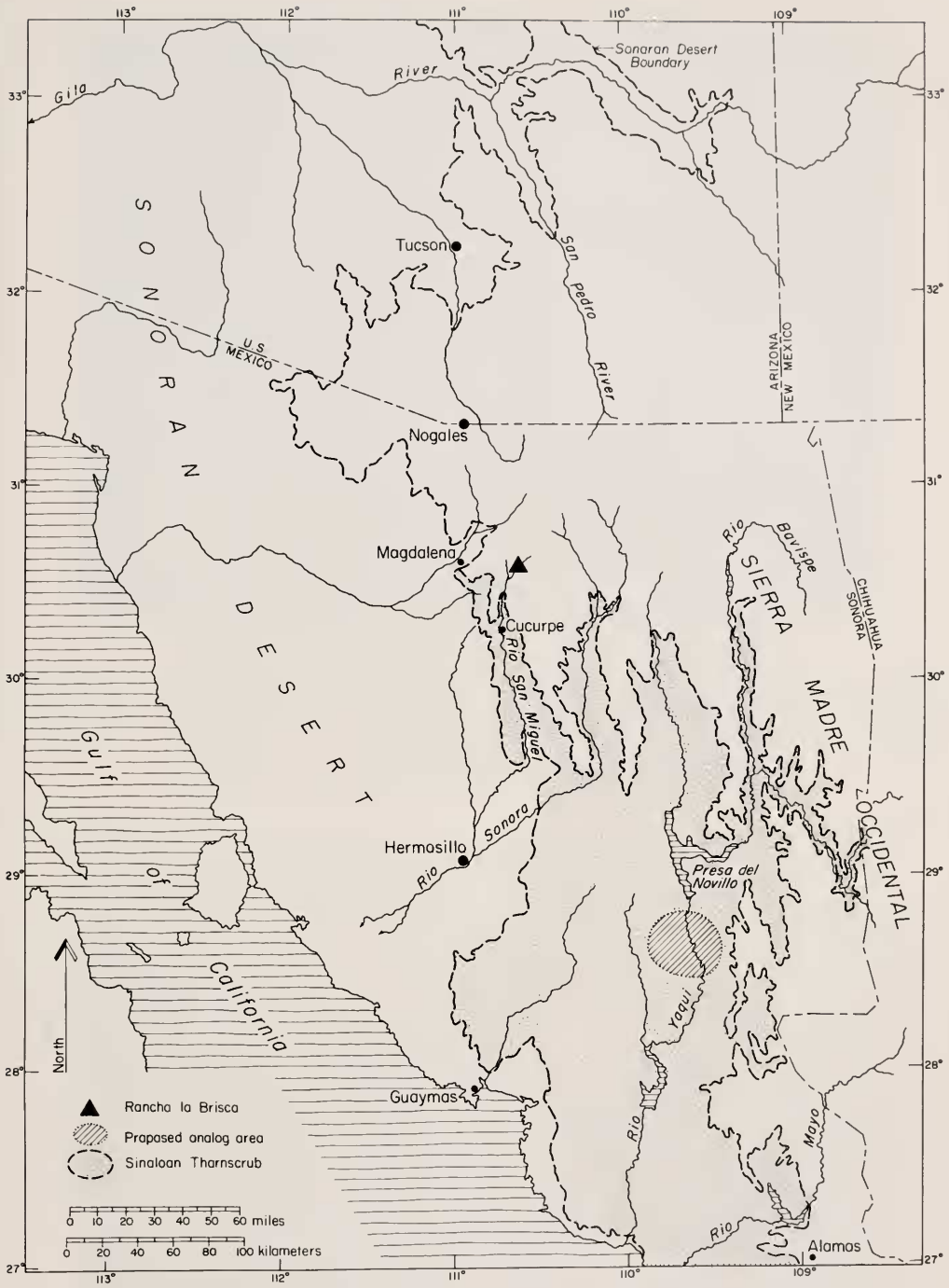

FIGURE 1. Map of Sonora and adjacent Arizona. Stippled area is Sinaloan thornscrub vegetation after Brown and Lowe (1977). Boundary of Sonoran Desert after Shreve (1964).

itation is 466.8 mm, with 64% falling from June through August. These records are based on only a few years of data (1942–1946), but are similar to longer records for Cucurpe and Arizpe.

Between Rancho Agua Fria and Rancho la Brisca, the stream has incised into a narrow canyon in the coarse, well-indurated stream gravels. Near la Brisca, the canyon

FIGURE 2. Saracachi Ciénega in April 1977. *Rana "pipiens"*-complex (Leopard Frog) and *Kinosternon sonoriense* (Sonoran Mud Turtle) are common. *Pseudemys scripta* (Yaqui Slider) was observed in the open water in middle of photo. The trees on edge of water are *Salix nigra* (Goodding Willow), *Celtis reticulata* (Netleaf Hackberry), and *Prosopis velutina* (Velvet Mesquite). The columnar cactus on hill in background is *Carnegiea gigantea* (Saguaro).

FIGURE 3. General view of the Rancho la Brisca vertebrate fossil locality in April 1976. Deposits are on the hillside in the center of photo obscured by trees. Most of the trees are *Prospis velutina* (Velvet Mesquite), with a few *Quercus emoryi* (Bellota).

FIGURE 4. Unit 2 of the Rancho la Brisca vertebrate fossil locality. Fossil bone was weathering out of the fine-grained sediments in lower center of photo. Screen wash samples came from this area as well.

widens where the fossils were found, about 15 m above the canyon floor in a small unit of remnant sediments deposited on the gravels (Fig. 4). There are three well-defined sedimentary units in the stratigraphic section: (1) a lower buff mudstone with a little gravel, about 3 m thick; (2) a middle buff mudstone with less gravel, about 2 m thick; and (3) an upper reddish gravel, about 2 m thick. Bone was found in the lower two units in fine clays with sparse gravel up to about 10 mm in size. The bone is well-mineralized and mostly dark brown or black. Fragile specimens (e.g., frog ilia and snake vertebrae) show no signs of transport damage, suggesting in situ deposition. Samples from the two mudstones, extracted for pollen using both acid and heavy liquid extraction techniques, were sterile (R. S. Thompson and V. Markgraf, *personal communication*). Two deposits with similar lithologies and perched positions on the rim of the valley were seen within 5 km of the la Brisca site (R. S. White, *personal communication*).

ANNOTATED ACCOUNT OF FOSSIL TAXA

Class Osteichthyes—Bony Fishes
Order Cypriniformes—Minnows and Minnowlike Fishes
Family Catastomidae—Suckers
Catostomus wigginsi Herre and Brock—Opata Sucker

Material.—Maxilla, dentary, metapterygoid and ceratohyal.

Comments.—The fossils are from suckers of 80–115 mm standard length (SL). Comparative material of *C. wigginsi* (UMMZ 202388-S) is from the Río Santo Domingo at Rancho la Brisca.

Castostomus wigginsi is distinguished from the other five described species of Mexican *Catostomus* on characters of the dentary. The gnathic ramus of the dentary is more attenuate in *C. wigginsi* than in *C. clarki* (Desert Sucker) and bears a narrower groove for the labial cartilage. The gnathic sensory canal pore is not united with the crest for Meckel's cartilage to form a single complex structure as it is in *C. bernardini* (Yaqui Sucker) and *C. conchos* (Río Conchos Sucker), and the sensory pore is nearer the symphysis than is the crest for Meckel's cartilage. The coronoid process of the dentary is not deflected laterally as in *C. plebeius* (Río Grande Sucker); the posterior surface of the gnathic ramus is flat, not concave; the anterior end of the groove for the labial cartilage is visible in mesial view. *Catostomus wigginsi* is distinguished from *C. insignis* (Sonoran Sucker) by the highly elevated coronoid process in the former.

The dorsal keel of the maxilla of *C. wigginsi* is distinct from that of *Catostomus plebeius* in that it is flexed anteroventrally. In *C. wigginsi* the ceratohyal is long and slender, much less robust than in *C. plebeius, C. bernardini,* or *C. insignis,* and is without ventral ornamentation as in *C. insignis.* The la Brisca fossils agree with *C. wigginsi* in the above characters.

This is the only fossil record for *C. wigginsi* and the genus *Catostomus* reported from Mexico. *Catostomus wigginsi* is endemic to the Río Sonora and its tributary, the Río San Miguel, although there is a single record for the Río Moctezuma, tributary to the Río Yaqui (UMMZ 161467; Hendrickson et al. 1980). *Catostomus bernardini* has been collected once in the Río Sonora system (UMMZ 161453); it is otherwise known from Pacific slope drainages from the Río Yaqui to the Río Sinaloa. Since *C. wigginsi* has not been collected subsequently from the Río Yaqui drainage, nor *C. bernardini* from the Río Sonora, we regard these records as erroneous.

The Opata Sucker is a small species of *Catostomus*; breeding individuals are less than 110 mm SL at Rancho la Brisca today. It is typically associated with moderate to swift currents and sand or gravel substrate in rivers or small streams with pools or other cover.

Family Cyprinidae—Minnows

Agosia chrysogaster Girard—Longfin Dace

Material.—Right pharyngeal arch lacking posterior limb and fourth tooth.

Comments.—The fossil resembles recent material of *Agosia chrysogaster* from the Río San Miguel drainage (UMMZ 202389-S). The pharyngeal arch is attenuate and its anterior limb is shorter than its dentigerous portion. The teeth bear weak hooks and are moderately compressed, but are not as compressed or crowded as in species of *Pimephales* and *Campostoma*; they are more closely spaced than in *Notropis ornatus* (Ornate Shiner) or *N. formosus* (Beautiful Shiner). The fossil differs slightly from recent material of *A. chrysogaster* in having smaller terminal hooks on the teeth.

Agosia occurs naturally in the Gila and Bill Williams drainages of southwestern United States (Minckley 1973) and in the Magdalena, Sonora, Yaqui, and Sinaloa river systems of Mexico. These are all considered to be *A. chrysogaster,* although the Mexican populations may be a distinct species (Miller 1958). *A. chrysogaster* is abundant in most Sonoran Desert streams below 1500 m (Minckley 1973, Hendrickson et al. 1980); it has not been reported previously as a fossil.

Genus and species indeterminate

Material.—A fragmentary left opercle.

Comments.—This bone can be assigned to the Cyprinidae based on the shape of the dilator process; the articulating cotyla and most of the body of the bone are missing. The specimen is too large to be *Agosia, Campostoma, Notropis formosus, N. ornatus,* or *Pimephales.* It agrees in size with *Gila,* but diagnostic features are lacking.

Cyprinidontiformes—Pupfish and Killifish
Family Poeciliidae—Topminnows
Poeciliopsis occidentalis Baird and Girard—Gila Topminnow
or
P. monacha-occidentalis—All-female Topminnow

Material.—Two left opercles.

Comments.—The dilator process of the opercle is rounded and does not extend beyond the dorsal margin of the opercle. The articulating cotyla is oblong dorsoventrally and matches modern material in shape and arrangement of its supporting struts. *Poeciliopsis occidentalis* and *P. monacha-occidentalis* are distinguishable on dental characters which, unfortunately, are not evident on the fossil material.

The natural range of the Gila Topminnow includes the Gila River of Arizona and New Mexico and the Pacific coastal drainages of Sonora south to the Río Mayo. In the Mexican part of its range, it is host to the all-female hybridogenetic form, *P. monacha-occidentalis*. Both forms occur at Rancho la Brisca today, although *P. monacha-occidentalis* was rare (2.2%) in our field collection which constitutes one of the northernmost records of the all-female form (*see* Moore et al. 1970). *Poeciliopsis occidentalis* was widespread and abundant in two surveys of Sonoran fishes (Branson et al. 1960, Hendrickson et al. 1980). It is associated with moderate current below riffles or along stream margins and characteristically occurs over sandy substrates (Minckley 1973). We collected it in the Saracachi Ciénega (Fig. 2).

This is the only fossil poeciliid reported from Mexico. Alvarez and Aguilar (1957) described a fossil poeciliid, *Poeciliopsis maldonadoi,* from deposits of unknown age (possibly Recent) in El Salvador. Some of that material later proved to be of the genus *Poecilia,* and *P. maldonadoi* may prove to be a synonym of the living species *P. turrubarensis* (Rosen and Bailey 1963).

Class Amphibia—Amphibians
Order Anura—Toads and Frogs
Family Bufonidae—Toads
Bufo alvarius Girard—Colorado River Toad

Material.—Frontoparietals (Fig. 5A), scapula (11599), ilia (3; 11600; Fig. 5B).

Bufo cf. *alvarius*

Material.—Dentaries (2; 11601), exoccipital, nasal, vertebrae (5; 11603–11604), humeri (2; 11602), radioulna.

Comments.—The fossils are from toads of 110–160 mm snout–vent length (SVL). Today only *B. alvarius* and *B. marinus* (Marine Toad) reach this and larger sizes. *Bufo woodhousei bexarensis* (Friesenhahn Cave Toad), an extinct late Pleistocene form in Texas, reached body lengths of 160 mm, but had a narrow frontoparietal with tubular dorsal ornamentation (Mecham 1959, Tihen 1962*a*) quite different than the la Brisca fossil. *Bufo alvarius* and *B. marinus* are in the *B. valliceps* (Gulf Coast Toad) species group of Tihen (1962*b*). Both species have wide frontoparietals shaped similar to those of the fossil, but *B. marinus* has heavier, more rugose dorsal ornamentation with prominent ridges oriented obliquely to the anterior-posterior axis of the bone (Fig. 5A). The anterior edge of the frontoparietal in our reference specimens is more squared-off than in the fossil. The ilia referred to *B. alvarius* have a broader dorsal prominence without the pronounced knob of *B. marinus* (Fig. 5B). The scapula of *B. alvarius* differs from that of *B. marinus* in that the articular surface is slightly smaller, and in that the acromial portion is relatively narrow. The larger la Brisca toad fossils could all be from *B. alvarius*, but *B. marinus* cannot be eliminated from consideration on the bones listed as *B.* cf. *alvarius*.

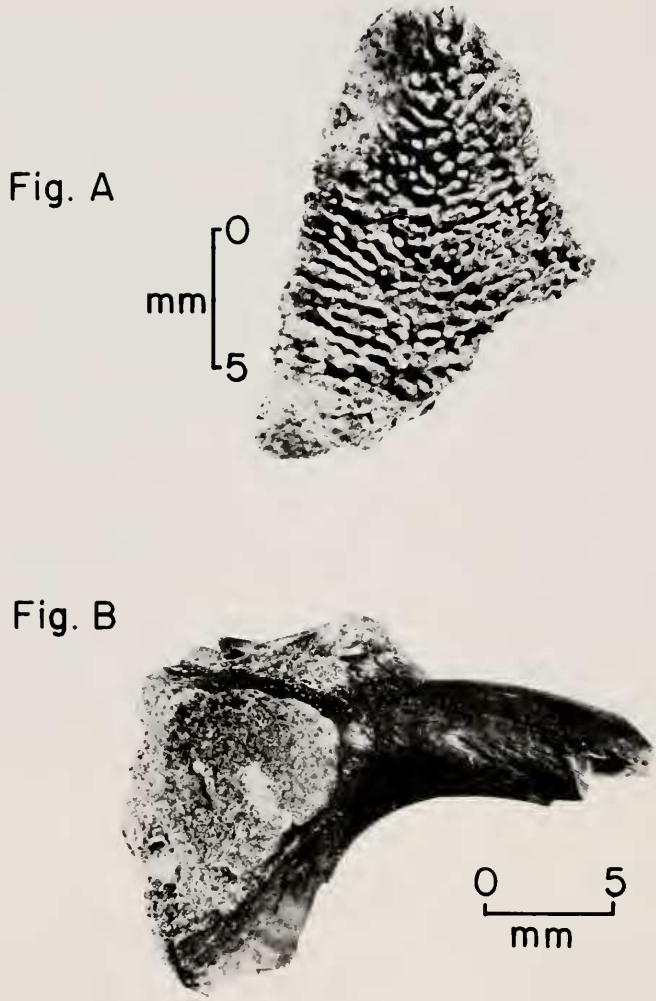

FIGURE 5. *Bufo alvarius* (Colorado River Toad). A. Right frontoparietal, B. Right ilium (UALP 10151).

This is the only Rancholabrean fossil record for *B. alvarius*. Lindsay (1984) reported *B. alvarius* from Irvingtonian deposits from the mouth of the Colorado River in the Gulf of California at El Golfo, Sonora (C. A. Shaw, *personal communication* 1985). Tihen (1962*a*) identified *Bufo* cf. *alvarius* from the Blancan Benson (=Post Ranch) Fauna in Cochise County, Arizona. Johnson et al. (1975) dated this fauna at 3.1 million years ago using the paleomagnetic stratigraphy in the San Pedro River Valley. *Bufo alvarius* is a large toad restricted to desertscrub and thornscrub plant communities in the Sonoran Desert from southern Arizona to northern Sinaloa (Fouquette 1970). It presently occurs near the la Brisca fossil site. *Bufo marinus* is a toad of more tropical environments that reaches its northern limit in southernmost Sonora.

Bufo cf. *cognatus* Say—Great Plains Toad

Material.—L. humerus.

Comments.—The humerus lacking the medial crest was from a female toad of about 60 mm SVL. The bone was relatively poorly ossified, and the radial condyle was unfused. The fossil is similar to the humeri of reference *B. cognatus* of the same size, although it is slightly more robust. *Bufo cognatus* was reported as a Late Wisconsin fossil from Friesenhahn Cave and the Groesbeck Local Fauna in Texas (Holman 1969*a*).

Bufo cognatus occurs from the Great Plains south into south-central Mexico and west to southeastern California, Baja California, and most of Sonora.

Bufo cf. *kelloggi* Taylor—Little Mexican Toad

Material.—Humeri (6L, 3R; 11605), sacral vertebra.

Comments.—The fossils are from individuals of 30–35 mm SVL. All appear to be males, although the medial crest is only weakly developed in *B. kelloggi.* The humeri of *B. retiformis* and *B. punctatus* are not as well ossified at this size. *Bufo debilis* is closer in size to *B. kelloggi,* but most mature at 40–45 mm SVL. Male *Leptodactylus melanonotus* are of similar size, but have better developed medial crests, more flattened shafts between the middle and the radial condyle (eminentia capitalis of Gaup 1896), and the lateral crest and epicondyle are equally well-developed.

Bufo kelloggi has not been reported previously in the fossil record. *Bufo kelloggi* is the smallest toad in the *Bufo punctatus* group of Ferguson and Lowe (1969) which also includes *B. punctatus, B. retiformis,* and *B. debilis.* It is found in coastal subtropical lowlands from Nayarit to as far north as central Sonora in the vicinity of Hermosillo, with an outlying population near Santa Ana (Hulse 1977). The la Brisca site is northeast of its present range.

Bufo mazatlanensis Taylor—Sinaloa Toad

Material.—R. basioccipital/frontoparietal, humeri (2L; 11607), ilia (2L, 2R; 11606; Fig. 6).

Bufo species—Toad

Material.—Ethmoids (2), basioccipital, atlas, sacral vertebra, urostyle, humerus, radioulnae (3; 11610), tibiofibulae (5; 11609).

Comments.—The fused basioccipital and frontoparietal are from a toad of about 90 mm SVL. The frontoparietal is broad and moderately rugose without a well-developed ridge for cranial crests. *Bufo alvarius* also has a broad frontoparietal without a crest, but has a strongly papillose or echinate dorsal surface. The frontoparietal of *B. cognatus* is narrow with a well-developed cranial crest. The condyloid fossa lateral to the occipital condyle is relatively larger in *B. alvarius* than in *B. mazatlanensis* and *B. cognatus.* The fossil resembles reference *B. mazatlanensis.*

The humeri referred to *Bufo mazatlanensis* are from a female of about 65 mm SVL, and a male of about 82 mm SVL. The radial condyle is well-rounded; the ulnar or medial epicondyle is well-developed; the lateral crest and lateral epicondyle are present, but not protruding.

The ilia referred to *Bufo mazatlanensis* are all from toads of 75–80 mm SVL and have low, broad dorsal prominences that are fairly flat on top, rugose or not, and with a broad, deep ventral acetabular expansion (Fig. 6). The dorsal prominences of *B. alvarius, B. cognatus, B. woodhousei,* and *B. microscaphus* are higher. The ventral acetabular expansion of *B. alvarius* is deep, but not broad. The bones identified as *Bufo* species could all be from *B. mazatlanensis.*

Bufo mazatlanensis does not have a previous fossil record. It is a member of the *B. valliceps* group found in the tropical lowlands of northwestern Mexico from southern Sinaloa northward to central Sonora. The northernmost collections are from the narrows of the Río Sonora near Ures 140 km S of la Brisca.

Bufo punctatus Baird and Girard—Red-spotted Toad
or
Bufo retiformis Sanders and Smith—Sonoran Green Toad

Material.—Humeri (3R, 4L; 10150, 11608).

Comments.—These humeri are from mature male toads 45–55 mm SVL. The radial condyles are well-ossified. The male medial crests may be well-developed. Male

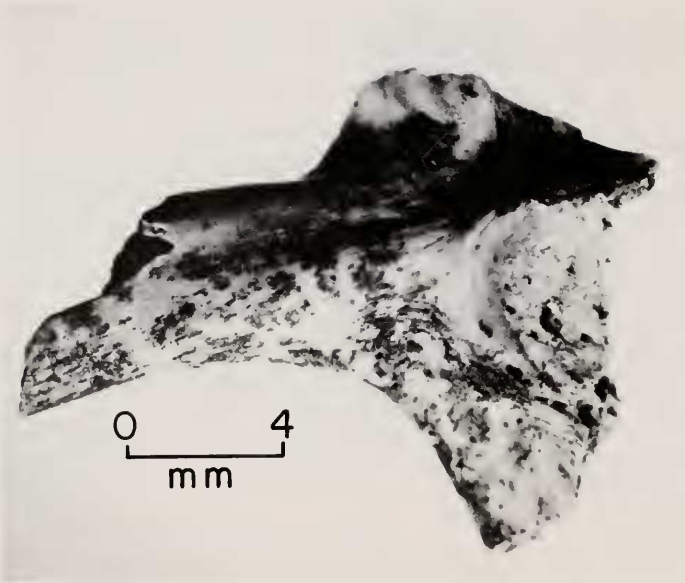

FIGURE 6. Left ilium (UALP 11606) of *Bufo mazatlanensis* (Sinaloa Toad).

Hylactophryne augusti are similar in size to the fossils, but the distal end of the humerus is relatively wider in this species, and the ulnar and epicondyles are well-developed. The humeri of most other *Bufo* and *Rana* are larger. The humeri of *B. punctatus* and *B. retiformis* are very similar to each other.

Bufo punctatus has been recorded from the Late Pleistocene and Holocene sediments of Dry Cave, Guadalupe Mountains, southeastern New Mexico (Holman 1970), and Howell's Ridge Cave, Little Hatchet Mountains, southwestern New Mexico (Van Devender and Worthington 1977). *Bufo punctatus* was reported from Late Wisconsin/Early Holocene deposits in Deadman Cave, Santa Catalina Mountains, Pima County, Arizona (Mead et al. 1984). Its bones were also found in packrat middens from the Sonoran Desert (Van Devender and Mead 1978). Two Late Wisconsin midden specimens from near Tucson, Arizona, were associated with a radiocarbon date of 12 130 ± 500 B.P. (radiocarbon years before present). Three Early Holocene midden specimens from the Whipple Mountains, California, were associated with dates of 10 930 ± 170 B.P. and 10 330 ± 300 B.P. *Bufo retiformis* does not have a previous fossil record.

Bufo punctatus is widespread in many habitats in the southwestern United States and Mexico. *Bufo retiformis* is a Sonoran Desert animal found from central Sonora north of Guaymas into south-central Arizona in Organ Pipe Cactus National Monument and on the Papago Indian Reservation (Hulse 1978).

Family Hylidae—Treefrogs

Hyla arenicolor Cope—Canyon Treefrog

Material.—Ilia (8L, 8R; 11636).

Hyla species—Treefrog

Material.—Vertebrae (2; 11611), sacral vertebrae (3; 11612), urostyles (2; 11613), radioulna, tibiofibula.

Comments.—The ilia are referred to *H. arenicolor* because: (1) the dorsal and ventral acetabular expansions (posterior and anterior pelvic spines of Gaup 1896) are subequal (the dorsal acetabular expansion is relatively smaller in *H. regilla*); (2) larger

size for maturity of the bone than in *H. eximia*; (3) relatively larger acetabulum for size of ilial head than in *H. cadaverina*; (4) a relatively low, broad dorsal prominence without a well-developed "knob" compared to *H. regilla* and *H. eximia. Pternohyla fodiens* is a larger treefrog which has the dorsal prominence oriented more dorsally than in *Hyla.* The fossils appear to have ossified at a relatively smaller body size (by 40 mm SVL) than does *H. arenicolor* today, and the "knob" on the ilial prominence is somewhat better developed. The la Brisca bones identified only as *Hyla* species could be from *H. arenicolor* as well. The sacral and trunk vertebrae resemble *Hyla,* but apparently are from mature individuals with body sizes of 35–40 mm SVL rather than today's 40–45 mm SVL. The urostyles, radioulna and tibiofibula are not sufficiently distinct to refer them to species.

The only previous Late Pleistocene and Holocene records for *Hyla arenicolor* are from Howell's Ridge Cave, New Mexico (Van Devender and Worthington 1977). Today it is widespread in canyon habitats in the mountains of the southwestern United States and Mexico and lives at the fossil locality today.

Pternohyla fodiens Boulenger—Burrowing Treefrog

Material.—Basioccipital, dentary, humerus.

Comments.—The basioccipital is referred to *P. fodiens* because: (1) the occipital condyle is a rounded knob rather than a flattened, elongate surface; (2) the epiotic eminence (terms follow Sanders 1953) is a prominent knob; (3) the prootic-transverse process is expanded; (4) the basioccipital is not fused to the frontoparietal as it is in adult *Hylactophryne augusti* and *Bufo mazatlanensis.*

The fossil dentary is referred to *P. fodiens* because: (1) it is larger than in *Leptodactylus melanonotus* and *Bufo kelloggi,* but smaller than in female *Hylactophryne augusti, Bufo alvarius, B. cognatus,* and *B. mazatlanensis*; (2) the medial flange is well-developed on the ventral border of Meckel's canal just anterior to the articular surface as in *Hyla,* but not *Bufo punctatus* and *B. retiformis*; (3) the dentary is thicker and curves more laterally and ventrally than *Hyla arenicolor.*

The fossil humerus has the broad distal end with the narrow shaft of the hylids, but it is larger (ca. 60 mm SVL) and stouter than adult *Hyla arenicolor* (45 mm SVL). The humerus of *Smilisca baudini,* a large subtropical treefrog, is not well-ossified at 65 mm SVL and has a broader distal end. Both the lateral or ulnar epicondyle project distally, while the radial condyle projects beyond both.

Pternohyla fodiens does not have a previous fossil record. It lives in dry subtropical habitats from Jalisco and Michoacan northward along the west coast of Mexico through Sinaloa and Sonora and into Arizona on the Papago Indian Reservation (Trueb 1969). The la Brisca site is probably just to the northeast of the nearest Sonoran populations.

Family Leptodactylidae—Tropical Frogs

Hylactophryne augusti (Duges)—Barking Frog

Material.—Scapula, tibiofibulae (3; 11640; Fig. 7).

Comments.—The fossils are from frogs of about 45–55 mm SVL. *Hylactophryne augusti* is sexually dimorphic with females reaching 90 mm SVL and males about 55 mm SVL. Reference skeletons of female *H. augusti* of 63 mm, 67 mm, and 89 mm SVL, as well as of many species of *Eleutherodactylus* and *Leptodactylus,* were available for comparison.

The scapula was referred to *H. augusti* because: (1) the acromion and glenoid portions of the scapula are not parallel as in *Rana*; (2) the anterior margin in the "waist" is less curved than in *Bufo* and *Scaphiopus*; (3) the notch between the acromial and glenoid portions of the scapula is relatively broad and angled; (4) the articular surface is relatively large.

Bufo and *Scaphiopus* (Pelobatidae) have relatively short tibiofibulae with the ends much wider than the middle. *Rana* (Ranidae) and *Hyla* (Hylidae) have longer, slender tibiofibulae that are flexed in the middle. The fossils and the leptodactylid reference

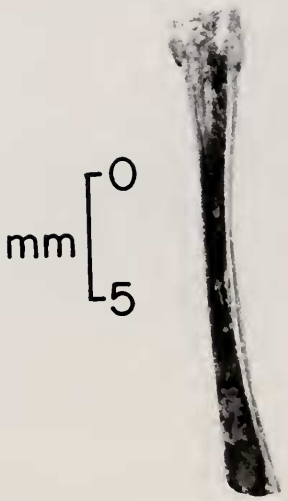

FIGURE 7. Tibiofibula of *Hylactophryne augusti* (Barking Frog).

specimens are moderately long and have straighter shafts with the ends and middle less disparate in size than in *Bufo* and *Scaphiopus* (Fig. 7). The distal end of the la Brisca fossil is missing, but the proximal end has well-ossified epiphyses with prominent lateral ridges similar to those on our reference leptodactylids. This articular surface in bufonids, pelobatids, ranids, and hylids is less ossified and usually separates from the shaft in maceration. The fossils are somewhat more robust than the reference specimens.

Hylactophryne (as *Eleutherodactylus*) *augusti* was reported from Late Wisconsin deposits in Frieshenhahn Cave, Bexar County (Mecham 1959) and Schulze Cave, Edwards County (Holman 1969*b*), Texas. *Hylactophryne augusti* is a secretive, rock-dwelling frog that is found in many habitats from southeastern Arizona (Bezy et al. 1966), southeastern New Mexico, and central Texas south through Mexico to the Isthmus of Tehuantepec (Zweifel 1967). In Arizona, it is rare in habitats similar to the la Brisca fossil site.

Leptodactylus melanonotus (Hallowell)—Sabinal Frog

Material.—Vertebrae (2; 11617), ilia (3R, L; 11616), scapula, humerus (R, L; 11614), radioulna (11615), tibiofibulae (5).

Comments.—The vertebrae were referred to *L. melanonotus* because: (1) of the small size (ca. 40 mm SVL); (2) the broad neural arch that is not flattened dorsally (as in *Bufo kelloggi*); (3) the relatively large neural canal; (4) the round transverse processes; (5) the relatively short centrum (larger in *Hyla*).

The fossil ilia are easily separated from those of anurans other than ranids and leptodactylids by the presence of a dorsal crest. The fossils can be separated from small *Rana* (ca. 33 and 39 mm SVL) by the dorsal crests being lower and the dorsal prominence being well-ossified without the porous texture of immature bone. They are referred to *Leptodactylus melanonotus* rather than male *Hylactophryne augusti* because of the well-developed dorsal prominence and small size.

The scapulae of leptodactylids and ranids differ from those of other anurans by the glenoid surface being shifted medially, such that it parallels that acromial surface. The fossil scapula was referred to *L. melanonotus* rather than *Rana* because it is

relatively short and broad and is from a very small, mature individual (ca. 35 mm SVL).

The fossil humeri were from individuals of about 33 mm and 37 mm SVL and were referred to *L. melanonotus* rather than other small anurans (*Bufo kelloggi, Gastrophryne olivacea,* hylids) because of the exceptionally well-developed medial crest of males. The fossil radioulna is referred to *L. melanonotus* because of its very small size and stockiness. The tibiofibulae were referred to *L. melanonotus* because of their small size, straightness, and relative thickness in the center of the shaft.

Leptodactylus melanonotus does not have a previous fossil record. It is a tiny frog in a tropical family found from central Sonora south into Central America. It is the northernmost species of *Leptodactylus; Hylactophryne* is the only other leptodactylid that occurs farther north. The nearest population of *Leptodactylus melanonotus* to the la Brisca site is southeast of Hermosillo. In southern Sonora, it lives in subtropical riparian habitats with perennial surface water.

Family Microhylidae—Narrow-mouth Toads

Gastrophryne cf. *olivacea* (Hallowell)—Great Plains Narrow-mouth Toad

Material.—Sacral vertebrate (2; 11620), ilia (2R, L; 11619), humeri (2R, 2L; 11618).

Comments.—The sacral vertebrae are small with the transverse processes expanded into wings, but not fused to the urostyle as in *Scaphiopus.* The sacral vertebra of *Bufo kelloggi,* another small fossorial "toad," is similar, but does not have the paired anterior cotyles.

The ilia of *Gastrophryne* are very distinctive and differ from other small anurans including *Acris, Bufo, Hyla* and *Pseudacris* in the following combination of characters: (1) the head of ilium is at sharper angle with the shaft; (2) dorsal acetabular expansion is greatly reduced; (3) ventral acetabular expansion is moderately deep but very broad. The humeri are also very distinctive and exhibit the following characters: (1) well-ossified at a very small size; (2) the shaft is relatively straight; (3) the lateral epicondyle is very poorly developed; (4) the lateral crests poorly developed or absent; (5) the posterior surface opposite the ulnar condyle is rounded rather than flattened.

Gastrophryne olivacea has been reported from the Sangamon Clear Creek local fauna, Denton County, Texas (Holman 1969*a*). This species is widespread in grassland habitats from the Great Plains to south-central Arizona; and south in subtropical lowlands through Sonora and Sinaloa to Nayarit (Nelson 1972). It probably lives near the la Brisca site today.

Family Pelobatidae—Spadefoot Toads

Scaphiopus couchi Baird—Couch's Spadefoot Toad

Material.—Atlas, vertebrae (2; 11624), ilia (2; 11623), scapula, radioulnae (2; 11621), tibiofibula (11622).

Scaphiopus species—Spadefoot Toad

Material.—Ilia, radioulnae (5).

Comments.—The atlas is referred to *Scaphiopus* because it has short broad cotyles (glenoid cavities of Gaup 1896) that are separated medially, and to *S. couchi* rather than *S. hammondi* because the neural arch is relatively smooth and the posterior condyle is usually fused. The vertebrae are from individuals of 60–70 mm SVL and referred to *Scaphiopus* because the neural spine is absent; there is a well-developed spine on the posterior margin of the neural arch, and the condyles and cotyles are rounded and relatively small. Again, the condyles are fused as in *S. couchi* and not *S. hammondi.*

The ilia are from individuals of 70–75 mm SVL and referred to *Scaphiopus* because the dorsal prominence is lacking. In *S. couchi* the ventral acetabular expansion is broader where the shaft meets the acetabulum than it is in *S. hammondi.* The ilia

identified as *Scaphiopus* species are less complete, but are from individuals of 65–70 mm SVL and could be from *S. couchi* as well.

The fossil scapulae have the glenoid surface posterior to the acromial surface as in *Bufo, Hylactophryne,* and *Scaphiopus,* and not medial as in *Rana.* The anterior margin is curved into the "waist" as in *Bufo* and *Scaphiopus,* but not broad and angled as in *Hylactophryne.* In *Scaphiopus,* the articular surface is relatively small, and the acromial surface is relatively narrow. *Scaphiopus couchi* has a slender scapula that broadens and becomes better ossified with age. *Scaphiopus hammondi* has a broader scapula that is in some ways more similar to *Bufo.* The fossil was from an individual approximately 50 mm SVL.

The fossil radioulnae are referred to *S. couchi* because: (1) of large size (ca. 75 mm SVL); (2) the "neck" is very broad with a well-developed crest on the ulna; (3) the olecranon and capitulum on the proximal end are relatively narrow. The radioulnae identified as *Scaphiopus* species are from smaller individuals and could represent *S. couchi* as well.

The tibiofibulae of *Scaphiopus* are distinctive because the tibia and fibula are fused into an arc on the proximal end where they contact the distal end of the femur, and the cartilaginous ends are simple and not ossified. In other anuran families, the tibia and fibula are separated more at the proximal end, and the cartilaginous articular surfaces are well-developed and can become well-ossified at maturity. The fossil is referred to *S. couchi* rather than *S. hammondi* because it is from a large individual and because the center portion of the bone is relatively thick.

Scaphiopus cf. *couchi* was reported from Late Pleistocene or Holocene deposits of Bishop's Cap, (Brattstrom 1964) and Howell's Ridge Cave (Van Devender and Worthington 1977), New Mexico. *Scaphiopus couchi* was reported in the Late Wisconsin/ Early Holocene deposits in Deadman Cave, Pima County, Arizona (Mead et al. 1984). Its bones were found in an Early Holocene packrat midden dated at 8150 ± 260 B.P. from near Wellton, Yuma County, Arizona (Van Devender and Mead 1978). *Scaphiopus couchi* is widespread in many habitats from the southern Great Plains west to southwestern California and south to Baja California, Nayarit, and central Mexico (Wasserman 1970). It probably lives at the la Brisca site today.

Family Ranidae—Frogs

Rana "pipiens" Shreber-Complex—Leopard Frog

Material.—Maxillae (2R, 2L; 11626), dentaries (2R, L; 11627), ethmoid, trunk vertebrae (3; 11632), sacral vertebrae (5; 11633), ilia (17; 11631), urostyles (7), fused pelvis, ischia (2), coracoid, scapulae (6R, 2L; 11628), humeri (2R, 2L; 11629), radioulnae (4R, 2L; 11630), tibiofibulae (2).

Comments.—The fossil maxillae are referred to *R. "pipiens"* because: (1) relatively large teeth (smaller in *Hyla*) are present (lacking in *Bufo*); (2) moderate size; (3) relatively smooth surface (rugose in *Pternohyla*). The dentary is referred to *R. "pipiens"* because the flange on the ventral edge of Meckel's groove posterior to the coronoid process is broad and not indented dorsally. The fossil ethmoid is thin and high compared to *Bufo* and *Hylactophryne.* The fossil vertebrae have broad, oval cotyles and condyles and the prezygapophysial surfaces are strongly angled dorsally. The sacral vertebrae are referred to *R. "pipiens"* because they possess an anterior condyle rather than a cotyle (*Bufo, Hylactophyrne, Hyla, Leptodactylus, Pternohyla*); they are not fused to the urostyle (*Scaphiopus*), and the transverse accessory processes are not expanded distally into "wings" (*Scaphiopus, Gastrophryne, Bufo kelloggi*). The ilia are referred to *R. "pipiens"* because: (1) the dorsal crest is well-developed; (2) the dorsal prominence is at a sharper angle than in leptodactylids (*Eleutherodactylus, Hylactophryne, Leptodactylus*); (3) the dorsal acetabular expansion is slightly higher than the ventral acetabuler expansion. The urostyles are referred to *R. "pipiens"* because of the (1) high dorsal coccygial spine along most of the body; (2) large oval vertebral canal above oval paired anterior cotyles (glenoid cavities); (3) relatively little space between the cotyles and the anterior end of the coccygial spine.

The fossil scapulae are referred to *R.* "*pipiens*" because: (1) the glenoid portion is shifted medially so that it parallels the acromial portion; (2) the size is large compared to *Leptodactylus melanonotus*. The fossil humeri are referred to *R.* "*pipiens*" because of a narrow shaft, and a small distal end of the lateral epicondyle. The fossil radioulnae are referred to *R.* "*pipiens*" rather than *R. tarahumare* (Tarahumara Frog). *Rana pipiens* (*sensu lato*) has been segregated into a complex of closely related species that inhabit virtually all aquatic habitats in North America. No attempt was made to distinguish the fossils from the southwestern species in this complex (*R. berlandieri, R. blairi, R. chiricahuensis, R. magnaocularis, R. pipiens, R. yavapaiensis*; see discussion and references in Platz and Frost 1984). Leopard Frogs are common in the la Brisca area today (UAZ 42422). *Rana* "*pipiens*" is common in many paleofaunas that range in age from at least the Late Miocene to many southwestern Late Pleistocene faunas (Holman 1969*a*). The only previous fossil record in Mexico is from a Rancholabrean cave deposit in Tamaulipas (Holman 1969*c*).

Class Reptilia—Reptiles
Order Testudines—Turtles
Family Emydidae—Pond Turtles
cf. *Terrapene*—Box Turtle

Material.—L. peripheral.

Comments.—The fossil is the anterior half of the eighth or ninth left peripheral that is similar to some of the robust Rancholabrean box turtles (e.g., *Terrapene carolina putnami*). The bone is very thick and flared, with a well-developed dorsal trough, or "rain gutter." The fossil differs from *T. ornata* (Ornate Box Turtle) in its thickness and in that the sulci for the marginal scutes are not angled.

Although robust *T. carolina* have a rich late Pleistocene fossil record east of the Continental Divide (Milstead 1967, 1969), the only fossil box turtles from farther west are early Blancan (late Pliocene) *Terrapene* species (cf. *T. ornata*) and Rancholabrean *T. ornata* from Arizona (Moodie and Van Devender 1978). *Terrapene ornata* is found from the Great Plains to southeastern Arizona and into north-central Sonora. *Terrapene nelsoni* (Sonoran Spotted Box Turtle) is a Mexican species in the *T. ornata* group that barely enters southern Sonora from the south in tropical deciduous forest (Milstead and Tinkle 1967). Male *T. nelsoni* can have flared peripherals. *Rhinoclemmys pulcherrima* (Central American Wood Turtle) is a terrestrial and semi-aquatic neotropical emydid with a well-developed "rain gutter" that also enters southern Sonora.

Pseudemys scripta Schoepff—Yaqui Slider

Material.—Nuchal (10156, cast; Fig. 8), neural, pleural fragments (8; 10143, 10420–10421, 15445), peripherals (6; 10144, 11625), ilium, hyoplastron (15444).

Comments.—The la Brisca fossils are from a large emydine turtle and have the strong ridging characteristic of *Pseudemys scripta*. The lateral edges of the first vertebral scute are concave medially on the nuchal bone (Fig. 8). The anterolateral corners of this scute contact the lateral edge of the nuchal bones; the corners are more often well within the nuchal bone. We have not tried to refer the specimens to a modern or fossil subspecies of *P. scripta*, although the nuchal is not as thick and rugose as late Pleistocene specimens from east of the Continental Divide. An adult *P. scripta yaquia* collected from the Saracachi Ciénega (Fig. 2) is fairly small for the species (210 mm carapace length) and has a strongly flattened shell. Larger individuals, including an old melanistic adult, have been observed in the ciénega. The maximum adult size of this turtle is larger and the shells are more domed in the Río Yaqui and the Río Mayo. The fossil pleurals from Rancho la Brisca are from individuals of about 275 mm carapace length. One specimen has a fairly uniform thickness of 4.7 mm and is relatively flat, suggesting a flattened shell. Domed shells have pleurals that are more curved, and differentially thickened medially at the articular surface with the vertebral bones. The pleurals are somewhat thicker than modern shells of similar-sized individuals. The hyoplastron is from a small juvenile with large unfused areas between the bones of the plastron.

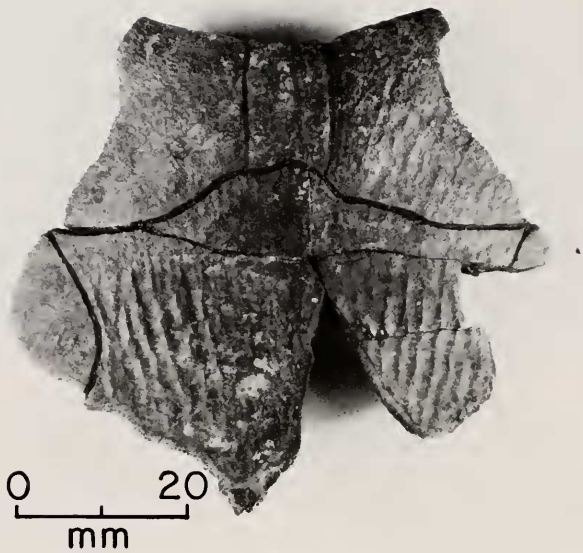

FIGURE 8. Nuchal bone (UALP 10156, cast) of *Pseudemys scripta* (Yaqui Slider).

Pseudemys scripta is a common fossil in deposits of Pliocene to late Pleistocene age in the eastern and central United States. The la Brisca specimen is the first Rancholabrean record west of the Continental Divide. Lindsay (1984) reported *Chrysemys* (=*Pseudemys*) from Irvingtonian deposits at El Golfo, Sonora, at the mouth of the Colorado River (C. A. Shaw, *personal communication* 1985). Presently, *P. scripta* is a sporadic inhabitant of the rivers of Sonora as far north as the Río Bavispe drainage (UAZ 39965) in northeastern Sonora.

Family Kinosternidae—Mud Turtles

Kinosternon flavescens Agassiz—Yellow Mud Turtle

Material.—Hypoplastron.

Comments.—The fossil *Kinosternon* material from la Brisca was identified by John B. Iverson, Earlham College. A single hypoplastron was referred to *K. flavescens* rather than to *K. sonoriense* because the sulcus for the femoral scute is parallel to the posterior margin.

Fossils of *Kinosternon flavescens* have been reported from late Hemphillian and Blancan deposits in Nebraska (Holman 1972), Kansas (Fichter 1969), and Texas (Rogers 1976). *Kinosternon arizonense,* described by Gilmore (1922) from the Blancan Benson Fauna, Cochise County, Arizona, is now considered a subspecies of *K. flavescens* (Iverson 1979*a*). *Kinosternon flavescens* was in the Folsom cultural levels at the Lubbock Lake Site, Lubbock County, Texas, at about 11 000 to 10 000 years ago (Johnson 1974). The la Brisca specimen is the only Rancholabrean record from west of the Continental Divide and Mexico.

Kinosternon flavescens presently ranges from Illinois south into northeastern Mexico and southwest to Arizona and Sonora. *K. f. arizonense* is locally common in a number of areas between Caborca and Hermosillo (J. Iverson, *personal communication* 1982). It has not been collected near la Brisca.

Kinosternon sonoriense LeConte—Sonoran Mud Turtle

Material.—Cervical vertebra (10422), nuchals (2; 10428), neurals (4; 10145, 10429), pygal (10423), 8th and 9th right peripherals (10424–10425), epiplastral fragments (12;

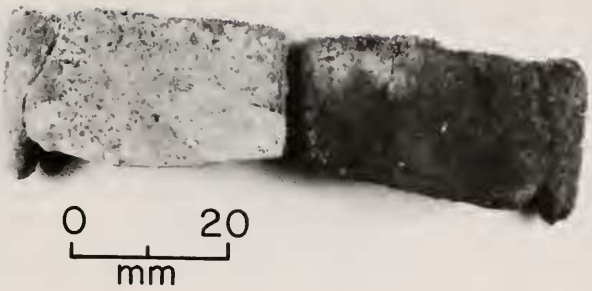

FIGURE 9. Left and right hypoplastra (UALP 10147) of *Kinosternon sonoriense* (Sonoran Mud Turtle).

10146, 10426), hyoplastra (8; 10147, 10427, 11137), hypoplastra (10148, 11138; Fig. 9), xiphiplastra (10149).

Kinosternon species—Mud Turtle

Material.—Dentary, humeri (2), femora (3), ilium, ischia (3), neurals (5), suprapygal, pleural fragments (71; 15435, 15439–15440), peripherals (61; 15441–15443), epiplastra (3), hyoplastra (10; 15437), hypoplastra (7), xiphiplastra (2; 15436).

Comments.—Most of the *Kinosternon* specimens identified to species are referred to *K. sonoriense*. The sutures on the right eighth peripheral bone show that the ninth marginal scute is not raised as in *K. flavescens*. The most common fossils at the la Brisca site are *Kinosternon* species; most of these are probably from *K. sonoriense*.

Kinosternon sonoriense is a common aquatic turtle in southern Arizona, Chihuahua, and northern Sonora (Iverson 1976); it is replaced by *K. alamosae* and *K. integrum* (Alamos and Sinaloan Mud Turtles) in southern Sonora. Numerous specimens have been collected from Sonora, including one from 5 km below Cucurpe in the Río San Miguel (UAZ 36509), and a series from the Saracachi Ciénega (TRV 2716; Fig. 2). It occurs in the stream below the la Brisca site today. *Kinosternon sonoriense* has no previous fossil record.

Order Squamata—Lizards and Snakes
Suborder Sauria—Lizards
Family Iquanidae—Iguanid Lizards
cf. *Callisaurus draconoides* Blainville—Zebra-tailed Lizard

Material.—Anterior half of frontal.

Comments.—This incomplete specimen resembles *Callisaurus draconoides* in (1) size; (2) the deeply excavated ventral surface; (3) the ventrolateral edges having heavy angular surfaces; (4) the relatively narrow anterior end and a relatively broad interorbital width. *Sceloporus* (several species) and *Holbrookia texana* (Greater Earless Lizard) are broader to the anterior. The ventral surface of the frontal is relatively shallowly excavated in *Sceloporus* and *Holbrookia maculata* (Lesser Earless Lizard). The interorbital portion of the frontal in *H. maculata* is very thin. The only previous fossil record for *Callisaurus draconoides* is from Late Wisconsin/Early Holocene deposits in Deadman Cave, Santa Catalina Mountains, Pima County, Arizona (Mead et al. 1984). This cursorial lizard is a Sonoran Desert species most often found in desertscrub and thornscrub habitats. In the la Brisca area, it follows sandy washes up into oak woodland.

Sceloporus cf. *clarkii* Baird and Girard—Clark's Spiny Lizard

Material.—Dentary, parietal, jugal.

Comments.—The dentary is from a large lizard in the *Sceloporus spinosus* group based on (1) size; (2) tricuspid tooth crowns; (3) transversely expanded tooth bases; (4) Meckel's canal closed, but not fused; (5) dentary relatively deep below Meckel's canal. The teeth are more slender than *S. magister* (Desert Spiny Lizard) and relatively larger than the large subspecies of *S. undulatus elongatus* (Northern Plateau Lizard), or *S. occidentalis* (Western Fence Lizard). The parietal and jugal also compare well with *S. clarkii,* but are less diagnostic. *Sceloporus* cf. *clarkii* was reported from Late Wisconsin/Early Holocene deposits in Deadman Cave, Santa Catalina Mountains, Pima County, Arizona (Mead et al. 1984). *Sceloporus clarkii* lives in habitats ranging from subtropical thornscrub in Sinaloa and southern Sonora to oak woodland in the Sierra Madre and in southern Arizona. It occurs today near the fossil site.

Suborder Serpentes—Snakes
Family Colubridae—Colubrid Snakes
Hypsiglena torquata (Günther)—Night Snake

Material.—Vertebra.

Comments.—This small colubrid was identified as *Hypsiglena torquata* on the following characters: (1) small size; (2) condyle and cotyle small and round; (3) neural spine moderately high; (4) accessory processes short, pointed, and oriented anteriorly; (5) relatively short vertebrae, and zygosphene curved down from the anterior. *Sonora semiannualata* (Ground Snake) and *Chionactis occipitalis* (Banded Sand Snake) have lower neural spines and more elongate vertebrae. *Chilomeniscus cinctus* (Shovel-nosed Snake) has longer accessory processes that are more perpendicular to the long axis of the vertebrae. *Hypsiglena torquata* was common in late Pleistocene and Holocene sediments in Howell's Ridge Cave, southwestern New Mexico (Van Devender and Worthington 1977). *Hypsiglena torquata* was reported from the Late Wisconsin/Early Holocene deposits in Deadman Cave, Pima County, Arizona (Mead et al. 1984). It has been found in eight packrat middens of Late Wisconsin and Early Holocene age from the Grand Canyon south into the Sonoran Desert in Arizona and California (Van Devender, Phillips, and Mead 1977; Van Devender and Mead 1978; Mead and Phillips 1981). *Hypsiglena torquata* is widely distibuted in habitats ranging from woods and desertscrub to pine forests (Van Devender and Lowe 1977).

Masticophis cf. *mentovarius* (Dumeril, Bibron and Dumeril)—Tropical Whipsnake

Material.—Middorsal vertebrae (20; 10152, 10430, 11139; Fig. 10), cervical vertebrae (5; 11634).

Comments.—Most of these vertebrae are from a very large colubrid snake; e.g., centrum lengths of 7.0–8.3 mm ($\bar{x}$ = 8.0 mm, n = 16) for mid-dorsal vertebrae (Fig. 10) and 6.4–6.7 mm ($\bar{x}$ = 6.5 mm, n = 4) for cervical vertebrae. Sonoran colubrids reaching this size include *Drymarchon corais* (Indigo Snake), *Masticophis* (several species), and *Pituophis melanoleucus* (Bullsnake). *Spilotes pullatus* (Tropical Ratsnake) is a large colubrid that occurs farther south in Mexico. The la Brisca fossils differ from those of *Pituophis melanoleucus* and *Spilotes pullatus* in being more elongate and the cotyle and condyle are round and much smaller. The average centrum length/neural arch width (cl/naw) ratio for the large la Brisca vertebrae is 1.24 (range 1.21–2.32, n = 15) for mid-dorsal vertebrae. A small vertebrae (cl = 6.36 mm) has a cl/naw ratio of 1.41. This is the upper range for *Drymarchon corais* (Auffenberg 1963) and within the range of *Masticophis.* A sample of 20 middorsal vertebrae averaged 1.49 (range 1.45–1.53) in a *M. flagellum* (Red Racer, Coachwhip) of 1076 mm SVL (TRV 433: Mexico: Sonora: 4.3 km E Navojoa) and 1.30 (range 1.23–1.42) in a specimen of *M. mentovarius* (Tropical Whipsnake) of 1570 mm SVL (TRV 1735: Costa Rica: Guanacaste Province). The la Brisca specimens are referred to *Masticophis* rather than *Drymarchon corais*

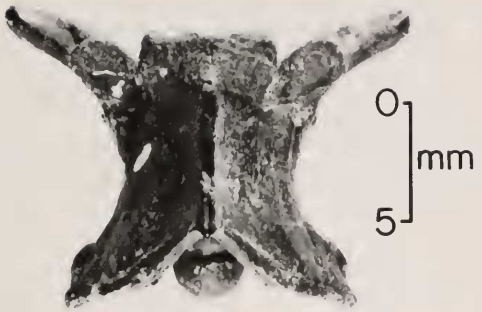

FIGURE 10. Vertebra (dorsal view) of *Masticophis* cf. *mentovarius* (Tropical Whipsnake).

because: (1) the neural spine is much lower and longer and lacks the bevelled anterior edge (ibid); (2) the accessory processes are longer and oblique to the anterior as viewed from above (they are lateral in *D. corais*); (3) the cotyle and condyle are round and relatively smaller. The la Brisca specimens are from a snake of about 1500 mm SVL, which is close to the maximum sizes for several species of *Masticophis* (*M. flagellum, M. bilineatus,* and *M. taeniatus*; Wilson 1970). *Masticophis mentovarius* reaches 1886 mm SVL (Johnson 1977, 1982). Although the record size for the northern subspecies *M. m. striolatus* is only 1120 mm SVL (Johnson 1977), animals of at least 1600–1700 mm SVL have been observed in Sonora (H. Lawlor, *personal communication*). The vertebrae most closely resemble a large *M. mentovarius.*

Although vertebrae of *Masticophis* and *Coluber* are common late Pleistocene fossils (Auffenberg 1963, Brattstrom 1954, 1958, Hill 1971, Holman 1969*a,* Van Devender and Mead 1978), the only previous fossil record for *M. mentovarius* is from Holocene Cave deposits in Yucatan, Mexico (Langebartel 1953).

Masticophis flagellum and *M. bilineatus* (Sonoran Whipsnake) probably live at la Brisca today. *Masticophis m. striolatus* has been collected at Santa Ana de Yécora, Sonora (UAZ 40078; 270 km SSE la Brisca) and has been observed on the Río Yaqui east of Hermosillo (240 km SSE la Brisca).

Salvadora species—Patch-nosed Snake

Material.—Vertebra.

Comments.—The elongate, medium-sized vertebra is from *Salvadora.* The condyle, cotyle, and neural canal are relatively smaller than in similar-sized *Masticophis* or *Coluber,* but larger than in *Opheodrys* (Green Snake), which also has somewhat longer accessory processes. The vertebrae of *Salvadora hexalepsis* (Desert Patch-nosed Snake) and *S. grahamiae* (Mountain Patch-nosed Snake) are very similar. Late Wisconsin and Holocene fossils of *Salvadora* species are known from Dry Cave, Eddy County (Holman 1970) and Howell's Ridge Cave, Grant County (Van Devender and Worthington 1977), New Mexico, and Deadman Cave, Pima County, Arizona (Mead et al. 1984). Patch-nosed Snakes live in many habitats from desertscrub to Mexican pine-oak woodland. *Salvadora hexalepsis* probably lives near la Brisca today.

Thamnophis cf. *cyrtopsis* (Kennicott)—Black-necked Gartersnake

Material.—Vertebrae (2; 11141).

Comments.—The small natricine vertebrae are from a species of *Thamnophis,* and came from individuals with SVLs of about 350 mm and 570 mm. The vertebrae (and

often the external morphology) of *T. cyrtopsis* and *T. eques* (Mexican Gartersnake) are very similar, and apparently differ only in a more slender hypopophysis in *T. cyrtopsis*. *Thamnophis marcianus* (Checkered Gartersnake) has shorter vertebrae, shorter accessory processes, and broad hypopophyses. Both vertebrae compared best with *T. cyrtopsis*. *Thamnophis cyrtopsis* is a snake of rocky canyons from the upper edge of the desertscrub into pine forest in the Sierra Madre and southern Arizona. It is common in the la Brisca area today (UAZ 42359). The only previous fossil record for *T. cyrtopsis* is from Late Wisconsin and Early Holocene deposits in Howell's Ridge Cave, Hidalgo County, New Mexico (Van Devender and Worthington 1977).

Family Crotalidae—Rattlesnakes

Crotalus atrox Baird and Girard—Western Diamondback Rattlesnake

Material.—Vertebrae (2; 11140), centrum.

Comments.—The vertebrae are from a very large rattlesnake with (1) a broad zygosphene; (2) very large cotyle and condyle; (3) a high neural arch as viewed anteriorly. Measurements of the largest vertebra are cl = 7.33 mm, naw = 8.64 mm, cl/naw = 0.85. *Crotalus basiliscus* (Mexican Green Rattlesnake) has a narrower zygosphene, whereas *C. molossus* (Black-tailed Rattlesnake) has a flattened neural arch.

Late Wisconsin records for *Crotalus atrox* are from Friesenhahn and Miller's Caves, central Texas (Holman 1969*a*), and Dry Cave, southeastern New Mexico (Holman 1970). *Crotalus atrox* was reported from Late Wisconsin/Early Holocene deposits in Deadman Cave, Pima County, Arizona (Mead et al. 1984). It was found in an Early Holocene packrat midden dated at 10 330 ± 330 B.P. in the Whipple Mountains, southeastern California (Van Devender and Mead 1978). *Crotalus atrox* is widespread in many habitats below woodland and forest from the Texas Gulf Coast west to southeastern California and south into Mexico. *Crotalus molossus* is the common rattlesnake at la Brisca today, although *C. atrox* is probably not far away in more xeric habitats.

Class Aves—Birds

Order Anseriformes—Water Fowl

Family Anatidae—Ducks

Anas cf. *crecca* Linnaeus—Green-winged Teal

Material.—Coracoid, missing the proximal head.

Comments.—On the basis of its very small size, the coracoid seems best referred to the widespread small Green-winged Teal. *Anas carolinensis* is now considered to be conspecific with the Old World *A. crecca*. The only previous record for the Pleistocene of Mexico is from Jiminez Cave, Chihuahua (Brodkorb 1964, Messing in press).

Order Falconiformes—Eagles, Hawks, and Vultures

Family Accipitridae—Hawks, Kites, Harriers, and Eagles

cf. *Spizaëtos*—Hawk-eagle

Material.—Distal half of metacarpal 2, lacking articular surface.

Comments.—This specimen was identified by R. McKenzie as being near the Rancholabrean *Spizaëtos grinnelli* (Grinnel's Hawk-eagle), but somewhat smaller. Wing elements of the two living New World tropical species (*S. ornatus* and *S. tyrannus*) were not available for comparison. *Spizaëtos grinnelli* has been reported from Carpinteria and Rancho la Brea in California, and San Josecito Cave in Nuevo León, Mexico (Brodkorb 1964).

†Species indeterminate

Material.—Right digit 2, phalanx 2.

Comments.—The fossil is the size of an eagle (*Aquila*), but has some characters different from that genus. A reference specimen of *Haliaeetus leucocephalus* (Bald Eagle) was not available for comparison. It does not resemble *Cathartes* (Cathartid Vultures) or *Mycteria* (Storks), which Ligon (1967) has shown to be more closely related to each

FIGURE 11. Owl left tarsometatarsi, dorsal aspect: modern *Strix nebulosa* (Great Gray Owl) on left; Rancho la Brisca *S. brea* in center; holotype of *Strix brea* (La Brea Owl) from Rancho la Brea (LACM E9379) on right.

other than to true falconiforms. In the Pleistocene of North America there were numerous eagles and eagle-like vultures (Howard 1932), but their distal-most wing elements are undescribed.

Order Galliformes—Gallinaceous Birds
Family Phasianidae—Pheasants, Quails, etc.
Meleagris gallopavo Linnaeus—Common Turkey

Material.—Distal end of ulna.

Comments.—The fossil was included as a female *M. gallopavo* in Rea's (1980) summary of late Pleistocene and Holocene turkeys in the Southwest. The only other late Pleistocene record of *M. gallopavo* from west of the Continental Divide is from Arizpe, ca. 25 km SE of la Brisca. The extinct *M. crassipes* was widespread in the late Quaternary of the Southwest. Historically, *M. gallopavo* probably lived near la Brisca, although *M. g. merriami* (Merriam's Turkey) in Arizona and New Mexico appears to represent feral introductions from prehistoric domestic animals (Rea 1980).

Order Strigiformes—Owls
Family Strigidae—Typical Owls
†*Strix brea* Howard—La Brea Owl

Material.—Left tarsometatarsus missing proximal end (10157, cast; Fig. 11).

Comments.—The tarsometatarsus is from an owl the size of a male *Bubo virginianus* (Great-horned Owl). *Strix* is distinguished from *Bubo* by (1) more parallel lateral edges of the shaft; (2) the distal calcaneal ridge not converging with the internal ridge of the shaft. The extinct *Strix brea* is distinguished from the living species *S. nebulosa, S. occidentalis,* and *S. varia* by a more prominent tubercle for the attachment of the M. tibialis anticus being placed higher on the shaft (see Howard 1933). The la Brisca specimen was compared directly with the type and type series ($n = 9$) of *S. brea* at LACM (Fig. 11). The living *S. nebulosa* (Great Gray Owl) of northern hemisphere boreal forests has a shorter, stouter tarsometatarsus. Measurements of the la Brisca fossil are: proximal end of trochlea for digit 3 to distal end of tubercle for M. tibialis

anticus = 37.9 mm; width across trochlea = 15.99 mm. *Strix brea* has been found previously only in California at the Rancho la Brea (ibid.) and Carpinteria (R. McKenzie, *personal communication* 1978) asphalt deposits.

Order Passeriformes—Perching Birds
Family Fringillidae, Emberizinae—New World Sparrows, Finches, etc.
Genus and species indeterminate

Material.—Right coracoid missing base (11142).

Comments.—The coracoid is indistinguishable from *Junco* (juncos) and *Zonotrichia* (sparrows). Elsewhere, an indeterminant Emberizinae was reported from the Late Wisconsin/Early Holocene deposits in Deadman Cave, Pima County, Arizona (Mead et al. 1984). Several species in these genera occur in the la Brisca area as winter migrants.

Family Icteridae—Meadowlarks, Blackbirds, Orioles
Agelaius phoeniceus Linnaeus—Red-winged Blackbird

Material.—Right humerus missing head and ectepicondylar process (11161, cast).

Comments.—The specimen was compared with *Sturnella* (Meadowlarks, 2 species), *Dolichonyx oryzivorus* (Bobolink), *Xanthocephalus xanthocephalus* (Yellow-headed Blackbird), *Euphagus* (Blackbirds, 2 species), *Molothrus* (Cowbirds, 3 species), *Quiscalus* (Grackles, 2 species), *Icterus* (Orioles, 2 species), *Cassiculus* (Mexican Cacique), *Cacicus* (Cacique), and *Cardinalis cardinalis* (Cardinal). This species is well-represented in late Pleistocene sites (Brodkorb 1978), and occurs today in stream and ciénega habitats in the la Brisca area.

Class Mammalia—Mammals
Order Carnivora—Carnivores
Family Procyonidae—Raccoons, Coatis and Ringtails
Bassaricus species—Ringtail

Material.—RI^3.

Comments.—The tooth is a premolariform incisor which closely resembles that of the extant *Bassariscus astutus* in having the crown offset with the root to the posterior, and the internal face spathulate. In *Urocyon* and *Vulpes,* the tooth is more caniniform and not spathulate medially. The incisor of *Mustela* is similar, but blunter, less spathulate, and with the crown centered over the root.

Bassariscus sonoitensis is an extinct Wisconsin Ringtail known only from Papago Spring Cave, Arizona, and San Josecito Cave, Nuevo León, northeastern Mexico; *Bassariscus astutus* is known from 14 Late Wisconsinin faunas from California, Nevada, New Mexico, and Texas (Kurtén and Anderson 1980). Several additional records from Late Wisconsin/Early Holocene cave deposits in the Grand Canyon and Santa Catalina Mountains of Arizona have been reported (Mead 1981, Mead et al. 1984).

Order Artiodactyla—Even-toed Ungulates
Family Camelidae—Camels and Llamas
†*Camelops* species—Camel

Material.—Navicular (10153, cast; Fig. 12).

Comments.—The navicular is not fused with the cuboid and is from a large animal (Fig. 11). The bone does not resemble those of *Bison, Equus,* or any of the large cervids. The specimen is very similar to the navicular of a modern *Camelus dromedarius* (Dromedary) from Pakistan. It appears to be close to *Camelops hesternus* (Yesterday's Camel) in size, and larger than the extinct llamas (*Hemiauchenia* and *Paleolama*). *Camelops* species was reported from Irvingtonian deposits at El Golfo, Sonora (Lindsay 1984). *Camelops* species is known from a number of Rancholabrean localities in Arizona (Lindsay and Tessman 1974). *Camelops hesternus* was the common, widespread

FIGURE 12. Navicular of *Camelops* species (UALP 10153, cast).

camel in the late Pleistocene of the western United States. It has been reported from several localities in Arizona, including a packrat midden dated at 13 820 ± 220 B.P. from Vulture Cave in the western Grand Canyon (Mead and Phillips 1981).

Family Cervidae—Deer
Odocoileus hemionus Rafinesque—Mule Deer

Material.—Left antler (10444, cast; anterior half of RM_1 or RM_2).

Comments.—This antler is referred to *Odocoileus hemionus* rather than *O. virginianus* (White-tailed Deer) because: (1) the shaft is only moderately curved anteriorly and laterally; (2) the two tines at the first main fork are not greatly different in size (anterior tine = 17.4 × 14.7 mm, posterior tine = 23.4 × 18.3 mm). The basal bur is thickest to the anterior (37.3 × 32.1 mm). A small medial tine (38.0 mm long, 16.0 × 9.1 mm cross-section) is 37.4 mm above the bur. The base of the main fork is 134 mm above the bur. The antler is broken just above the main fork. The shaft below the fork is flattened (17.8 × 16.6 mm). The shaft above the fork is also flattened, but may be crushed. The molar fragment could be from *O. hemionus* as well.

Odocoileus is first recorded in North America and Arizona in the Blancan Land Mammal Age (Lindsay and Tessman 1974). *Odocoileus* species was reported from Irvingtonian deposits at El Golfo, Sonora (Lindsay 1984). *Odocoileus hemionus* has been reported from 15 Irvingtonian and Rancholabrean sites from Arkansas to British Columbia and California (Kurtén and Anderson 1980). This is the first Pleistocene record for Mule Deer from Mexico. *Odocoileus virginianus* presently lives in the la Brisca area, while *O. hemionus* occurs at lower elevations to the south and west.

Family Antilocapridae—Pronghorn Antelope
Capromeryx cf. *minor* Taylor—La Brea Pronghorn

Material.—LP^4 (15446, cast).

Comments.—This tiny molariform premolar is similar in size to *Capromeryx minor* (=*Breameryx minor*; Kurtén and Anderson 1980) based on comparisons with material in the LACM collections by George T. Jefferson. *Capromeryx minor* stood only 560 mm at the shoulder and weighed about 10 kg. Previous Rancholabrean records for *C. minor* are from Ingleside on the Texas Gulf Coast, Blackwater Draw, New Mexico,

FIGURE 13. Molar of *Bison* species (UALP 10154, cast).

and McKittrick, Rancho La Brea, and Schuiling Cave, California (ibid.). *Capromeryx mexicana* (Mexican Pronghorn) from the late Pleistocene of the Mexican Plateau was about the same size as *C. minor*. The only record of the genus for Arizona is *Capromeryx gidleyi* from the Irvingtonian Curtis Ranch fauna in the San Pedro Valley, Cochise County (Lindsay and Tessman 1974, Johnson et al. 1975).

†*Tetrameryx* species—Four-horned Antelope

Material.—LM^1 (11162, cast).

Comments.—The molar fragment was compared to the LACM collections by McKenzie and Jefferson and referred to *Tetrameryx* species on size and morphology. The fossil is from an animal smaller than *Oreamnos* (Mountain Goat), *Ovis canadensis* (Bighorn Sheep), and *Odocoileus* (Deer), but larger than *Antilocapra americana* (Pronghorn), *Stockoceros,* and *Capromeryx* (extinct pronghorns). The enamel pattern of the fossil was similar to that of the antilocaprids, but not to the other artiodactyls examined. *Tetrameryx* has five Irvingtonian and Rancholabrean species known from Texas or central Mexico (Kurtén and Anderson 1980). *Tetrameryx* species was reported from Irvingtonian deposits at El Golfo, Sonora (Lindsay 1984), and from Rancholabrean deposits at Tule Springs, Nevada (Mawby 1967).

Family Bovidae—Bovids
†*Bison* species—Bison

Material.—Lower molars (2, R, LM_1 or M_2; 10154, cast; Fig. 13), ungual phalanx.

Comments.—These teeth are from a large *Bison,* but species determination is not possible. Fossil *Bison* have been reported from a number of Rancholabrean sites in Arizona including Papago Springs and Ventana Caves (Lindsay and Tessman 1974). This is the first published report of *Bison* for Sonora, although it has been collected from several other sites (R. S. White, *personal communication*).

Order Perissodactyla—Odd-toed Ungulates
Family Equidae—Horses
†*Equus* cf. *tau* Owen—Pygmy Onager

Material.—$LI^{1 \text{ or } 2}$, $LM^{1 \text{ or } 2}$ (15447, cast), lower molar fragment (10155, cast), $RP_{3 \text{ or } 4}$ (15447, cast), lower molar fragment, second phalanx, thoracic vertebra.

Comments.—These remains are from a very small species of horse. The upper molar is worn nearly to the roots and was from a very old individual. The tooth is shorter on the anterior-posterior axis than the transverse axis (21.3 × 25.4 mm). *Equus tau* is characterized by a very short tooth row that was usually less than 120 mm in length (Kurtén and Anderson 1980). Measurements for the lower premolar from la Brisca are 29.6 mm × 16.2 mm. Most of the la Brisca fossils could be from *E. tau*, although some of them could be from the slightly larger *E. conversidens* (Mexican Horse).

Equus tau was the smallest species of New World onagers, or stilt-legged horses (subgenus *Hemionus*), as well as the smallest American *Equus* (ibid.). It is known from Irvingtonian and Rancholabrean deposits from the Valley of Mexico to Oklahoma, Florida, Texas, and Arizona (ibid.). *Equus* cf. *conversidens* was reported from Irvingtonian deposits at El Golfo, Sonora (Lindsay 1984). Both *E. tau* and *E. conversidens* were reported from Rancholabrean deposits in Papago Springs Cave, south-central Arizona (Skinner 1942).

†*Equus* species—Horse

Material.—R. femur.

Comments.—The femur is apparently from an immature individual of a large horse because it is similar in size to the femur of an adult *E. asinus* (Burro), but the epiphyses on both ends are not fused. Remains of large horses have been reported in a number of Rancholabrean deposits in Arizona (Lindsay and Tessman 1974). *Equus occidentalis* (Western Horse) was common in the latest Rancholabrean deposits in Ventana Cave on the Papago Indian Reservation, southwestern Arizona (Haury 1975).

Order Proboscidea—Elephants, Mastodons, Gomphotheres
Family Elephantidae—Mammoths and Elephants
†*Mammuthus* species—Mammoth

Material.—R. pisiform, thoracic vertebra.

Comments.—The vertebra is identified as *Mammuthus* species on the basis of its large size and its rounded, rather than sub-triangular shape as in *Mammut*. The pisiform has the more elongate shape of *Mammuthus* (Olsen 1972). Additional proboscidean remains not identifiable to genus include tusk and skull fragments, a fragment of a humerus, and several partial ribs. *Mammuthus* remains have been reported from many sites in Arizona (Saunders 1970) and are known from over 25 unpublished localities in Sonora (R. S. White, *personal communication* 1975). *Mammuthus imperator* (Imperial Mammoth) was reported from Irvingtonian deposits at El Golfo, Sonora (Lindsay 1984). *Mammuthus sonorensis* (Sonoran Mammoth) was described from Irvingtonian or Rancholabrean deposits from Arizpe, Sonora (Lindsay 1984), but has been considered a synonym of *M. columbi* (Columbian Mammoth; Kurtén and Anderson 1980). *Mammuthus columbi* was the common Rancholabrean elephant of the southwestern United States, although there is some question of its distinctness from *M. jeffersoni* (Jefferson's Mammoth; Kurtén and Anderson 1980).

Order Rodentia—Rodents
Family Heteromyidae—Kangaroo Rats and Pocket Mice
Dipodomys species—Kangaroo Rat

Material.—LM_2.

Comments.—The tooth is from a species of *Dipodomys* in the size range of *D. merriami* (Merriam's Kangaroo Rat) and *D. ordi* (Ord's Kangaroo Rat). Teeth of Kan-

garoo rats are common in fossil packrat middens from the Mohave Desert (Van Devender et al. 1977). *Dipodomys* species and *D. merriami* were identified from three Late Wisconsin and six Early Holocene packrat middens from the Sonoran Desert in southwestern Arizona and adjacent California (Mead et al. 1983). *Dipodomys* species and *Dipodomys* cf. *ordi* have been identified in Late Wisconsin sediments from Smith Creek Cave, Snake Range, eastern Nevada (Mead et al. 1982). *Dipodomys merriami* and *D. ordi* are widespread in desertscrub and desert-grassland habitats and probably occur near la Brisca today.

Family Cricetidae—Mice, Rats, Lemmings, and Voles
Neotoma species—Packrat

Material.—LM_2.

Comments.—This tooth is referred to *Neotoma* by being relatively large and high-crowned among rodents. The lophs are rounded (as in *N. albigula, N. lepida, N. micropus*) and not prismatic (as in *N. cinerea, N. mexicana, N. stephensi*; Harris 1984). *Neotoma albigula* (White-throated Packrat) was reported from Late Wisconsin/Early Holocene deposits in Deadman Cave, Pima County, Arizona (Mead et al. 1984). Teeth of *Neotoma* are common late Pleistocene fossils in ancient packrat middens in Arizona and California (Van Devender et al. 1977; Mead et al. 1983). Packrats live in virtually all habitats from desertscrub at sea level to montane boreal forests over 3000 m elevation. *Neotoma albigula* presently lives at la Brisca.

Onychomys species—Grasshopper Mouse

Material.—RM_1.

Comments.—The teeth of *Onychomys* can be separated from those of similar-sized *Peromyscus* (Deer Mouse) because they are higher crowned with more prominent cusps. *Onychomys* cf. *leucogastor* was in the Rancholabrean fauna from Papago Springs Cave, Santa Cruz County, Arizona (Skinner 1942). *Onychomys* species has been found in two Late Wisconsin packrat middens from Arizona: Wolcott Peak #5, Pima County, dated at 12 130 ± 500 B.P., and Brass Cap Point #1, Yuma County, dated at 11 450 ± 400 B.P. (Mead et al. 1983). Two species of Grasshopper Mice (*O. leucogastor* and *O. torridus*) are widespread in grassland, desert-grassland and desertscrub habitats in the southwestern United States and northern Mexico. Both species live near the fossil site today.

Sigmodon species—Cotton Rat

Material.—Maxilla with RM^{1-2}, RM^1 (11144), LM^1 (11143), dentary with RM_{1-3}.

Comments.—These specimens are from a medium-sized cricetid rodent and are referred to the genus *Sigmodon* because of the distinctive tooth morphology. *Sigmodon hispidus* (Hispid Cotton Rat), *S. ochrognathus* (Yellow-nosed Cotton Rat), and *S. minimus* (Red-bellied Cotton Rat) are present in southern Arizona and northern Sonora today. *Sigmodon hispidus* is now considered to be three species: *S. hispidus, S. mascotensis,* and *S. arizonae* based on different numbers of chromosomes (Zimmerman 1970); the form in northern Sonora is *S. arizonae.*

Sigmodon species was reported in Arizona from the late Pleistocene Rancholabrean Murray Springs Arroyo Fauna, Cochise County (Lindsay and Tessman 1974), from the Late Wisconsin/Early Holocene Deadman Cave, Pima County (Mead et al. 1984), and in the Early Holocene Wellton Hills #2 packrat midden, Yuma County (Mead, et al. 1983). *Sigmodon ochrognathus* and *Sigmodon* species were found in Wolcott Peak #2 packrat midden, a mixed Middle Holocene and Late Wisconsin sample from Pima County, Arizona (Mead et al. 1983).

TABLE 1. Vertebrates of the Rancho la Brisca local fauna (Late Pleistocene: Rancholabrean Land Mammal Age; Sangamon Interglacial) of Sonora, Mexico. † = Extinct.

Fish	Reptiles
Castostomus wigginsi—Opata Sucker	†cf. *Terrapene*—Box Turtle
Agosia chrysogaster—Longfin Dace	*Pseudemys scripta*—Yaqui Slider
Indeterminate cyprinid	*Kinosternon flavescens*—Yellow Mud Turtle
Poeciliopsis occidentalis—Gila Topminnow	*Kinosternon sonoriense*—Sonoran Mud Turtle
Poeciliopsis monacha-occidentalis—All-female Topminnow	cf. *Callisaurus draconoides*—Zebra-tailed Lizard
	Sceloporus cf. *clarkii*—Clark's Spiny Lizard
Amphibians	*Hypsiglena torquata*—Night Snake
Bufo alvarius—Coloardo River Toad	*Masticophis* cf. *mentovarius*—Tropical Whipsnake
Bufo cf. *cognatus*—Great Plains Toad	*Salvadora* species—Patch-nosed Snake
Bufo cf. *kelloggi*—Little Mexican Toad	*Thamnophis* cf. *cyrtopsis*—Black-necked Garter-snake
Bufo mazatlanensis—Sinaloa Toad	*Crotalus atrox*—Western Diamondback Rattlesnake
Bufo punctatus—Red-spotted Toad	
Bufo species—Toad	Birds
Hyla arenicolor—Canyon Treefrog	*Anas* cf. *crecca*—Green-winged Teal
Hyla species—Treefrog	†cf. *Spizaetos*—Hawk-eagle
Pternohyla fodiens—Burrowing Treefrog	Indeterminate falconiform—?Eagle
Hylactophryne augusti—Barking Frog	*Meleagris gallopavo*—Common Turkey
Leptodactylus melanonotus—Sabinal Frog	†*Strix brea*—La Brea Owl
Gastrophryne cf. *olivacea*—Great Plains Narrow-mouth Toad	Indeterminate Emberizinae—Junco or Sparrow
	Agelaius phoeniceus—Red-Winged Blackbird
Scaphiopus couchi—Couch's Spadefoot Toad	
Scophiopus species—Spadefoot Toad	Mammals
Rana "*pipiens*" Complex—Leopard Frog	*Bassariscus* species—Ringtail
	†*Camelops* species—Camel
	Odocoileus hemionus—Mule Deer
	†*Capromeryx* cf. *minor*—La Brea Pronghorn
	†*Tetrameryx* species—Four-horned Antelope
	†*Bison* species—Bison
	†*Equus* cf. *tau*—Pygmy Onager
	†*Equus* species—Horse
	†*Mammuthus* species—Mammoth
	Dipodomys species—Kangaroo Rat
	Neotoma species—Packrat
	Onychomys species—Grasshopper Mouse
	Sigmodon species—Cotton Rat

Faunal Analysis

A total of 493 bones representing 51 taxa of vertebrates from 29 families are identified from the Rancho la Brisca local fauna. The fauna includes fishes (5), anurans (12), reptiles (11), birds (7), and mammals (13). The fish, amphibians, and reptiles represent 60.8% of the species and 92.9% of the identified specimens, while birds were 13.7% and 1.8%, and mammals were 25.5% and 5.3%, respectively. These percentages are unusually low for mammals in late Pleistocene sites, but may be explained by the ancient sedimentary environment at la Brisca (see below).

Percentages of the total number of identified elements were used in the analyses because minimum number of individuals (MNI) does not reflect the abundance of some groups (e.g., snakes) very well, and it was not possible to compare fossils collected over a six-year period and deposited regularly into the collection in Mexico City. Most bones appear to represent separate individuals, with a few exceptions (e.g., the 20 vertebrae from *Masticophis* cf. *mentovarius*).

The fauna is strongly biased toward medium- and small-sized animals (i.e., less than 0.5 kg). The bones of *Leptodactylus melanonotus, Gastrophryne* cf. *olivacea,* and all of the fish are very small. There were only ten species of large animals, all except the eagle and hawk-eagle being mammals. These bones represent 19.6% of the species, but only 3.0% of the identified bones.

Nine (or ten, if the cf. *Terrapene* represents an extinct form) of the species (or 17.6–19.6% of the fauna) are extinct. Twenty bones from extinct animals account for 4.1% of the total. Warm blooded animals account for most of the extinction: birds, 28.6% of species and identified bones; mammals, 53.8% of species and 61.7% of identified bones. By contrast, 2.6% of the species and 1.0% of the bones of cold blooded animals are from extinct animals. None of the fish or amphibians, and perhaps only cf. *Terrapene* among the reptiles, were affected by the extinction at the end of the Late Wisconsin about 11 000 years ago (Martin 1973).

There is a strong bias in the fauna towards aquatic animals: 10 (19.6%) species and 69.9% of the identified bones. Besides fishes these include *Hyla arenicolor, Leptodactylus melanonotus, Rana "pipiens"*-complex, *Pseudemys scripta, Kinosternon flavescens, K. sonoriense, Thamnophis* cf. *cyrtopsis,* and *Anas* cf. *crecca.* The remainder of the anurans and the Red-winged Blackbird are considered semiaquatic because some period of their life history is associated with water. Mud Turtles and Leopard Frogs dominate the fauna, with 55.9% of the identified bones. The totals for the aquatic and semiaquatic animals combined are 49.0% of the species, and 87.2% of the identified bones. The terrestrial animals in the fauna represent 51.0% of the species, but only 12.8% of the bones.

Paleoenvironments

The Rancho la Brisca fauna is dominated by small, aquatic and semiaquatic animals that are found in permanent stream or cienega habitats. At least locally, the water was deep enough to support *Pseudemys scripta. Catostomus wigginsi* lives in stream pools with moderate current. The most abundant species, *Rana "pipiens"*-complex and *Kinosternon sonoriense,* also require fresh water. The association of the fauna and the fine-grained clay matrix of the la Brisca sediments suggest that the fossils were preserved in a well-developed cienega habitat (Hendrickson and Minckley 1984), similar to the nearby Saracachi Ciénega with its stream inlet, open pools, and marsh located in the center of a relatively open stream valley (Fig. 2). The riparian gallery forest near the inlet pools of the Rancho la Brisca paleocienega provided roosts for raptorial birds whose pellets would have been a source for the bones of smaller vertebrates preserved in the sediments. The permanent water probably attracted the large mammals and their predators. Occasional floods probably account for the minor gravel component in the otherwise fine-grained sediments. The la Brisca sediments, perched 15 m above the modern streambed, indicate the former base level of the Río Santo Domingo which has incised into the soft indurated stream gravels subsequent to the deposition of the la Brisca fauna.

Zoogeography

Many fishes of the Magdalena, Sonora, and Yaqui systems are closely related to or conspecific with species in the Gila River of Arizona and New Mexico (Miller 1958, Minckley 1973, Hendrickson et al. 1980). *Catostomus bernardini* of the Río Yaqui is allied to *C. insignis* of the Gila River. The distributions of *Agosia* and *Poeciliopsis* also indicate former connections between the rivers of Sonora and southern Arizona and New Mexico. *Kinosternon sonoriense* is common in most of the rivers of southeastern Arizona, northwestern Chihuahua and Sonora, further suggesting stream connections in the past.

By the late Pliocene, *Kinosternon flavescens* apparently reached the Gila River drainage in southeastern Arizona from the central United States. The Blancan fossils from the San Pedro River Valley were already differentiated into the Sonoran subspecies *K. f. arizonense* by about three million years ago (Iverson 1979*a*). This turtle has adapted its breeding activities to coincide with the intense summer rainy season rather than spring rains. Today it is found from south-central Arizona on the Papago Indian Reservation through central Sonora as far south as the Río Yaqui south of Guaymas (Iverson 1979*b,* Seidel 1978). The western drainages occupied by *K. f. arizonense* drain

southward and are isolated from the Gila-Colorado system (including the San Pedro River) to the north. The only permanent aquatic habitats in these areas are artificial stock ponds. *Kinosternon f. arizonense* probably evolved in southeastern Arizona and dispersed south into Sonora at a time when the San Pedro River and Sonoran systems were connected. The present, isolated populations in Arizona probably dispersed from Sonora during a warm, wet interstadial period, rather than directly from southeastern Arizona.

Pseudemys scripta is a large aquatic turtle found from the southeastern United States to western Texas, south to Central America, and up the western coast of Mexico into central Sonora and southern Baja California. It has a rich fossil record east of the Continental Divide, but has not been recorded in Pliocene or Pleistocene deposits in Arizona, although it has now been found in Irvingtonian and Rancholabrean deposits in Sonora. Apparently, *P. scripta* never dispersed from Mexico into Arizona, suggesting that the connections between river systems were short-lived, shallow streams. Considering the fossil record of the cold-blooded groups represented, the past stream connections probably began in the Late Pliocene providing multiple opportunities for dispersals of some animals.

Paleoclimates and Age of Fauna

Five animals in the fauna (*Bufo* cf. *kelloggi, B. mazatlanensis, Leptodactylus melanonotus, Pternohyla fodiens* and *Masticophis* cf. *mentovarius*) no longer live in the la Brisca area, but are present to the southwest and southeast in Sonoran desertscrub and Sinaloan thornscrub communities. *Bufo alvarius,* cf. *Callisaurus draconoides,* and *Sceloporus* cf. *clarkii* are other Sonoran elements in the fauna that live in desertscrub, thornscrub, or oak woodland/desert–grassland communities which are found in the Rancho la Brisca area today. *Hylactophryne augusti* is another animal that just reaches Arizona, but is widespread in central and eastern Mexico. The area where most of the species in the la Brisca fauna occur together today would be along the Río Yaqui near El Novillo east of Hermosillo (Figs. 1 and 14), about 240 km SSE of la Brisca.

The biota of the Sonoran Desert becomes more subtropical to the south and east as the number of freezes per winter decreases, and the total annual precipitation and the percentage of summer rainfall increase (Hastings and Turner 1965). The presence of subtropical Sonoran animals suggests that the la Brisca fauna lived in a climate with fewer winter freezes and substantially greater summer rainfall than occurs in the area today.

Fossil packrat middens provide detailed chronologies of vegetation and climate for the last 30 000 years for many desert areas in the southwestern United States (Van Devender and Spaulding 1979). The general Middle and Late Wisconsin (35 000–11 000 B.P.) paleoclimatic reconstruction from the midden record for the area between 32–36°N latitude includes mild winters with greatly increased rainfall and cool summers with greatly decreased rainfall. There was little summer rainfall in the present Sonoran Desert in western Arizona. A Middle Wisconsin packrat midden from west of Hermosillo, Sonora, recorded the expansion of some woodland trees into low areas in central Sonora during the last glacial period (Wells and Hunziker 1976). The la Brisca fauna, however, is more likely to reflect a thermal maximum during an interglacial with increased summer monsoons and an expansion of subtropical communities into north-central Sonora. The climate of the Late Holocene (4000 B.P.–present) was probably similar to the paleoclimate of the la Brisca fauna.

The Rancholabrean Land Mammal Age began at the end of the Yarmouthian Interglacial and the beginning of the Illinoian Glacial. Previously, an interstadial Rancholabrean fauna like that of la Brisca would have been placed in the Sangamon interglacial period between 125 000 and 70 000 years ago. At least ten Rancholabrean faunas in Florida have been assigned to the Sangamon interglacial, although few faunas in the western United States have been correlated with that period (Kurtén and Anderson 1980). However, the beginning of the Rancholabrean was recently correlated with the Brunhes normal magnetic polarity zone at about 690 000 B.P. (Kurtén and

FIGURE 14. Three miles above Soyopa on Río Yaqui between El Novillo and Tónichi in July 1983. *Leptodactylus melanonotus* (Sabinal Frog) live in moist side of river, *Pseudemys scripta* (Yaqui Slider) sun on exposed bank on far side of river. *Masticophis mentovarius striolatus* (Tropical Whipsnake) was observed on the slopes. Slope vegetation is mostly tropical deciduous forest with Sinaloan thornscrub on drier aspects and inland away from river. This area is 240 km SSE of la Brisca.

Anderson 1980, Lindsay et al. 1975). With the inferred length of the Illinoian Glacial, the correlation of the Rancholabrean with glacial/interglacial sequences is no longer clear. Sangamon faunas could actually correlate with any of the five or so earlier warm periods recorded in oxygen isotope sequences from deep-sea cores (Imbrie and Imbrie 1979). However, the arrival of *Bison* south of the continental ice sheets now appears to have been between 170 000 and 150 000 years ago (C. A. Repenning, *personal communication* 1984). The presence of *Bison* species places the fauna in the last interglacial, the traditional Sangamon.

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